



Proposal for a Research Program on

Breakwater Armour Layer Stability

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Proposal for a research program
on
“Breakwater armour layer stability”
by
Hans F. Burcharth

Objective: To develop design diagrams for stability of armour layers constructed of multilegged unreinforced armour units with macro shape like a twisted H (THB unit or modified Dolos).

Limitations: The design diagrams shall cover typical configurations of rubble mound structures in *shallow* water.

The design diagrams shall cover both hydraulic and *mechanical stability* given by probability distributions. The armour unit will be only the THB type optimized with respect to main dimensions of legs and trunk and with respect to possible introduction of macro surface roughness elements (Burcharth, 1983).

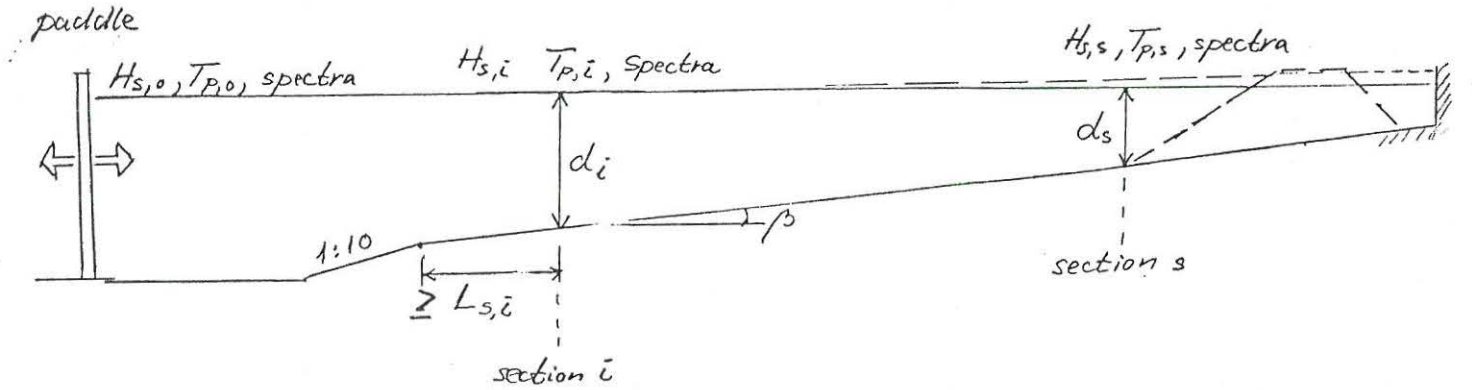
The reasons for focusing of this type of unit are the following:

- It is known from earlier studies (Burcharth 1981 and 1986) that a balance between hydraulic and mechanical stability can be obtained.
- It is known from the same studies that an excellent hydraulic stability is obtainable.
- THB units will most probably be suitable for repair of slender complex types of units.
- The technique and the experience from the Crescent City study are directly applicable.

Overall procedure: Three different geometries of the THB unit will be tested with respect to hydraulic stability and material stresses for a simple shallow water structure. Sea states in front of the structure ranging from non-breaking waves to wave breaking in a wide surf zone should be applied.

Model set-up and waves: Test will be 2-D tests (flume) on plane, sloping sea beds.

Waves will be generated in intermediate water depth ("deep water") at the paddle.



Waves should be characterized at the paddle and/or at a section situated app. $L_{s,i}$ from the beginning of the sloping sea bed (angle β).

- Two standard types of spectra (P-M and JONSWAP) with random phase component waves and one typical swell dominated type of spectrum (e.g. from U.S. Pacific coast) should be applied.
- To characterize the waves in front of the structure it is suggested that a parameter characterizing the non-linearity of the waves should be used. For this purpose an Ursell type parameter which for irregular waves should be defined by

$$\Pi_U = \frac{L_{s,s}^2 H_{s,s}}{d_s^3} \quad (1)$$

might be used.

Assuming shallow water waves in front of the structure and consequently

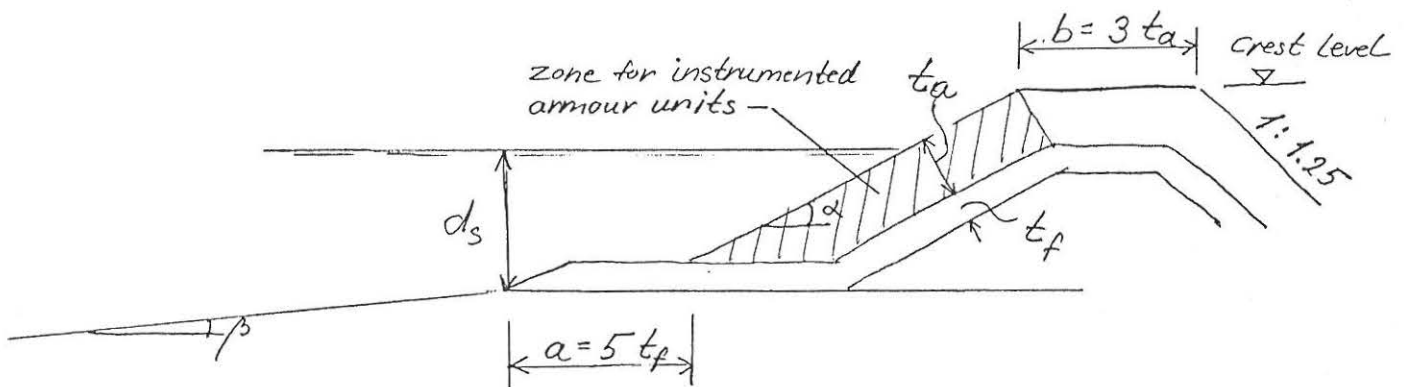
$$L_{s,s} \simeq T_{s,s} \sqrt{g d_s} \quad (2)$$

(1) takes the form

$$\Pi_U = \frac{g T_{s,s}^2 H_{s,s}}{d_s^2} \quad (3)$$

- All sea states should be recorded/calibrated without the reflecting break-water structure in the flume.
- SWL at the paddle should be kept constant throughout all testing and calibration.
- SWL variations at section s (in front of the structure) should be recorded.
- The width of the surf zone should be recorded for each sea state.
- "Stationary" SWL conditions should be obtained before conclusive recordings can be performed.
- Recorded waves at section s should be analyzed with respect to
 - varians spectrum
 - wave height distribution (zero down crossing def. of waves)
 - crest height distribution (zero down crossing def. of waves)
- Sea states in front of the structure should range from non-breaking waves to waves breaking over a wide surfzone.
- To cover the full range for hydraulic stability of the armour units as well as to be able to evaluate the residual capacity of the structure the significant wave height in front of the structure should reach 2.5 to 3.0 times the height of the modified Dolos (Burcharth et al., 1986)

The structure:



Armour Units: THB units waist ratios $r = 0.32, 0.38, 0.42$. Macro roughness surface elements might be applied. Mass app. 190-200 g for all types.

The same type of load cell can be used for all three types.

Packing density and number of units per unit area of slope should be optimized.

Filter layer: Two layers of quarry rock with mass of app. $1/5$ of the armour unit mass.

Core material: Fine, almost impermeable material (impermeable core will be on the safe side).

Slope angle: $\cot \alpha = 1 : 1.25, 1 : 1.5, 1 : 2.0, (1 : 3.0)$. Emphasis is put on the steep slopes because such slopes are probably the most economical.

Crest level: Crest level should correspond to max run-up level.

Test procedure: Whenever test series are repeated or the instrumented armour units are relocated the armour layer and the filter layer should be reconstructed.

A test series starts with the mildest sea state and gradually more severe sea states are applied. From the most severe sea state the tests are repeated in reverse order. Reconstruction should not take place within such a test series.

It is known that armour layer damage increases with the number of waves. Very little development in damage takes place after 5,000 - 10,000 waves. To save time in the testing normal test series should only contain the minimum number of waves necessary to obtain a reasonable statistical background for the analysis of armour unit stresses (app. 300-500 waves). Long test series (2,000 - 5,000 - 10,000 waves) should be applied for some of the more severe sea states. In this way the development of damage and failure as functions of time and sea state can be studied.

The hydraulic stability is studied by observing the number of units rocking and being displaced (visual observations and videofilming through glass walls in flume). Single frame cine technique might be used (see f. ex. Burcharth et al., 1986).

Strains are recorded from instrumented units.

Run-up should be recorded.

Toe stability should be studied by visual observations (video). Strengthening of the toe by applying heavier rock might be a necessity for some sea stages.

Waves and water levels are recorded as explained above.

Additional tests: To study the performance of the THB unit as a repair unit for rehabilitation of rubble mound structures a series of tests should be performed where the units are placed on underlayers of broken units of various types and sizes.

Cooperation between CERC and University of Aalborg:

Model testing: Sea bed slopes 1 : 50 : CERC.

Sea bed slopes 1 : 10 : AU

Before tests with sea bed slope 1 : 20 are performed the results of the 1 : 50 and 1 : 10 tests should be compared to verify if the parameters Π_U , $H_{s,s}/d_s$, $H_{s,s}/h$ give a unique description of the armour unit layer response. If this is the case then the number of tests with bed slope 1 : 20 can be reduced to checking the hypothesis.

FEM analysis of units : CERC.

Surface roughness study : AU.

Calibration (synchronizing) of test procedures at CERC and AU should be done by reproducing the well documented tests at NCR, Ottawa, with instrumented Dolosse in a simple deep water situation. Data will be made available by NRC.

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